ALL-SEASON AURORAL OBSERVATIONS WITH HiT&MIS:

NIGHTTIME ENERGY & FLUX RETRIEVAL OF AURORAL ELECTRONS AND PROGRESS TOWARDS SUNLIT CONDITIONS

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I.INTRODUCTION

Background

Sunlit auroral emissions are difficult to observe from the ground due to bright solar background.

A High-resolution spectrograph (~0.012 nm at 630 nm), **HiRISE[1]** (1999, Greenland)[2], has shown that daytime emissions can be extracted from sunlight-contaminated spectra.

Project Overview

Goal: Characterize auroral emissions and morphology differences between day and night, and across seasons

Approach: Continuous, all-season observations of atmospheric emissions

Duration: Jan 2025 - Current

Location: Swedish Institute of Space Physics (IRF)

Instrument : Ground-based spectral imager -- **HiT&MIS**

II. HiT&MIS

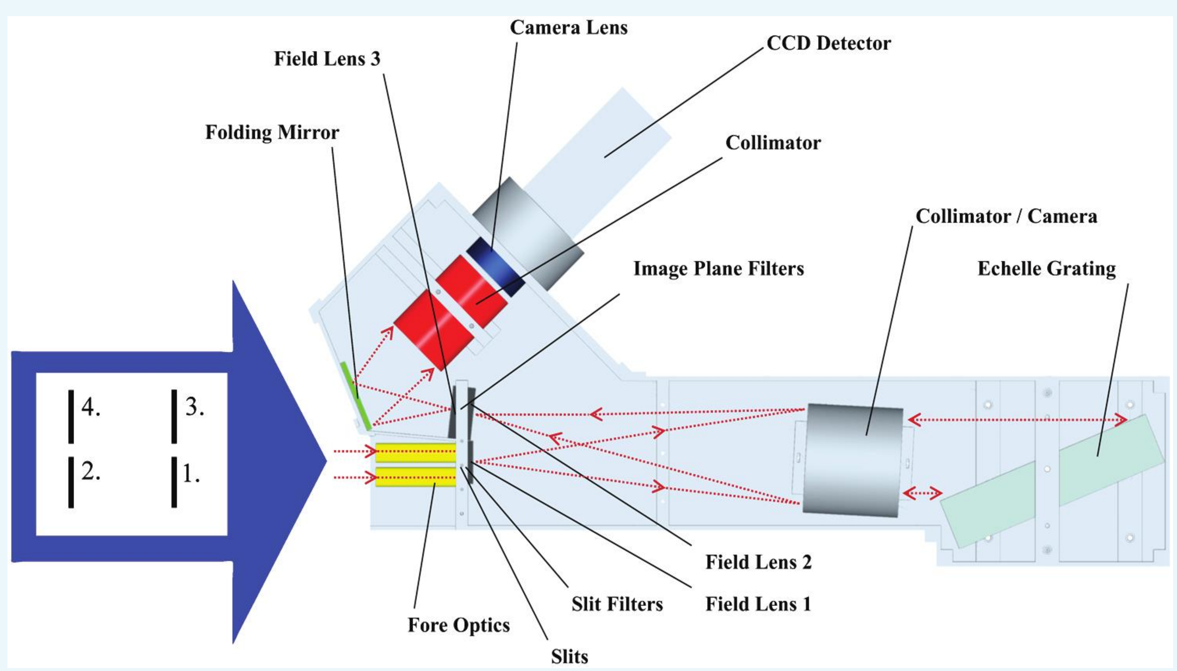


*Fig 1: Schematic of **High Throughput & Multislit Imaging Spectrograph** (Descendent of HiRISE).[3]*

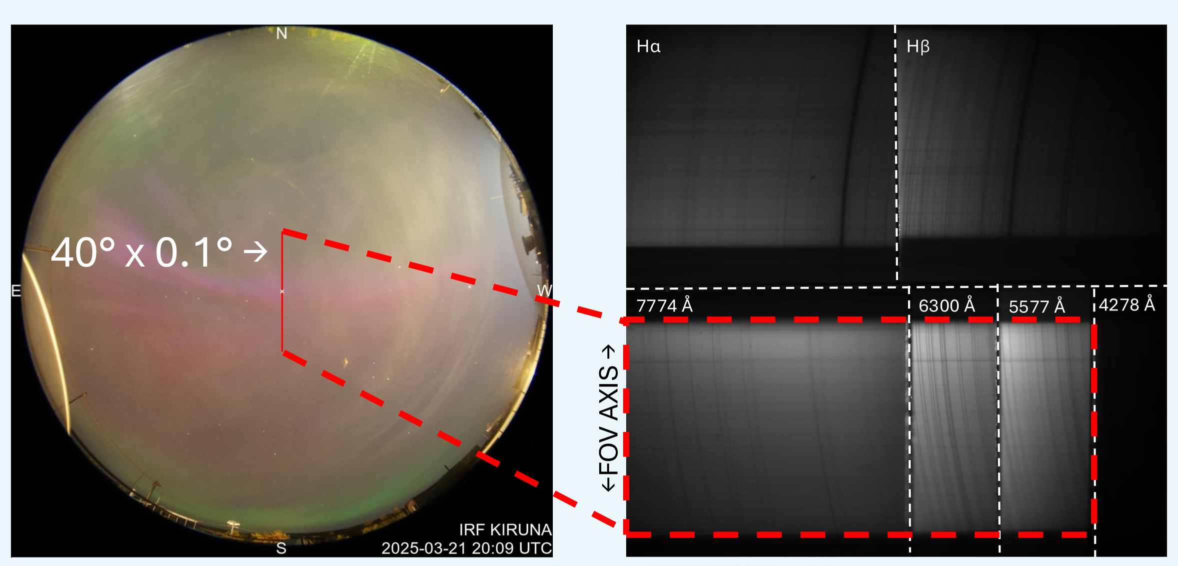


***Fig 2 : Left**- HiT&MIS FOV overlaid on all-sky[4] image.*
***Right**- Raw daytime HiT&MIS frame.*

III.DATA ANALYSIS PIPELINE

LEVEL 0 – Raw Data

LEVEL 1 - Calibration

L1A – segregate into individual panels, primary straightening, wavelength calibration, spatial calibration, convert to netCDF files

L1B – secondary straightening, dark correction

L1C – Photometric Calibration

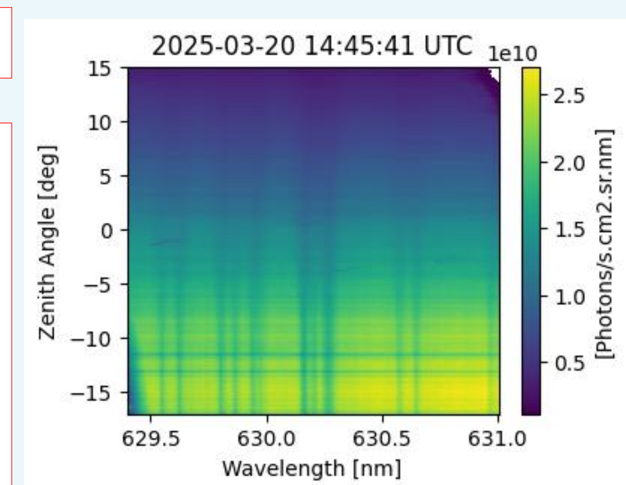
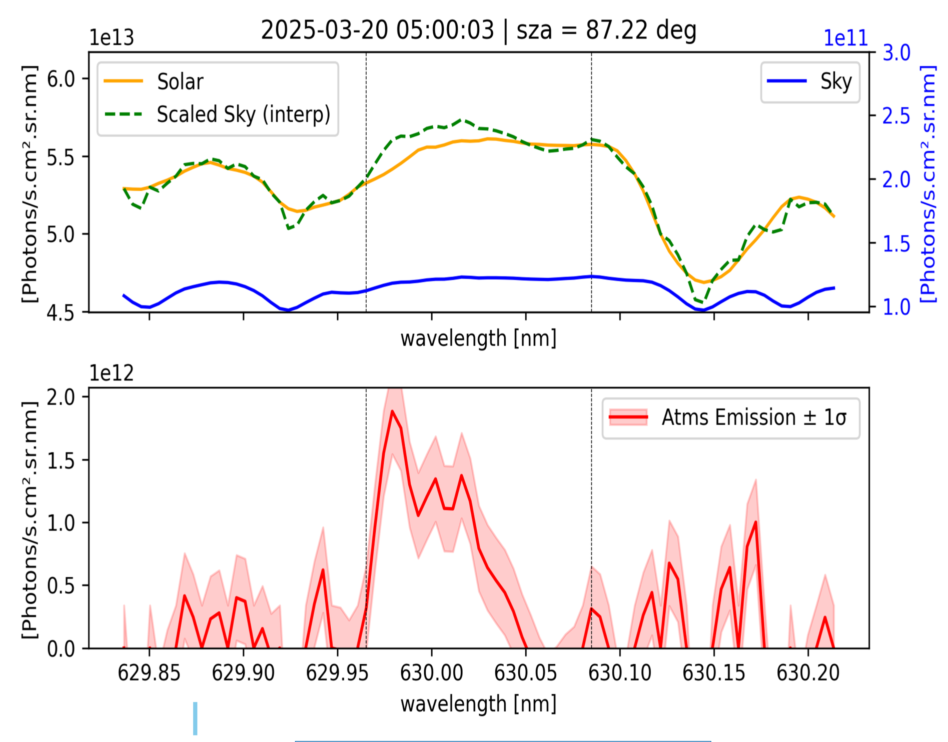


***Fig 3:** Sample of daytime Level 1 spectra from 6300 Å window.*

LEVEL 2 – Emission brightness

Daytime
(Solar Zenith Angle < 96°)

Nighttime
(Solar Zenith Angle > 96°)



$\mathcal{J}$(time, za)

LEVEL 3 – Q/E_o Retrieval using GLOW-2D[5]

Input
Date, UT, Position, $F_{10.7}$, α_{sp} ,Q, E_o

GlOW-2D
MSIS21 - Neutrals D_n, T_n
IRI20 – Electron D_e , T_e
IGRF14 – Geomag Params

Output
Densities, Emission Brightness ($\mathcal{J}$)

ERR( )
Compare measured & modeled brightness

Minimize ERR( )
By varying α_{sp} ,Q, E_o

$\Delta x > 10^{-10}$

$\Delta x \leq 10^{-10}$

Modeled Parameters
α_{sp} , Q, E_o

GLOSSARY

Q – Total Energy Flux
E_o – Characteristic Energy
D_x – Density (x = n(neutral), e (electron))
α_{sp} – Density Scale Factor (sp = species)
$\mathcal{J}$ – Emission Brightness
x – Fitting Parameters
Δx – Change in Fitting Parameter
ERR() – Error Function

IV.NIGHTTIME

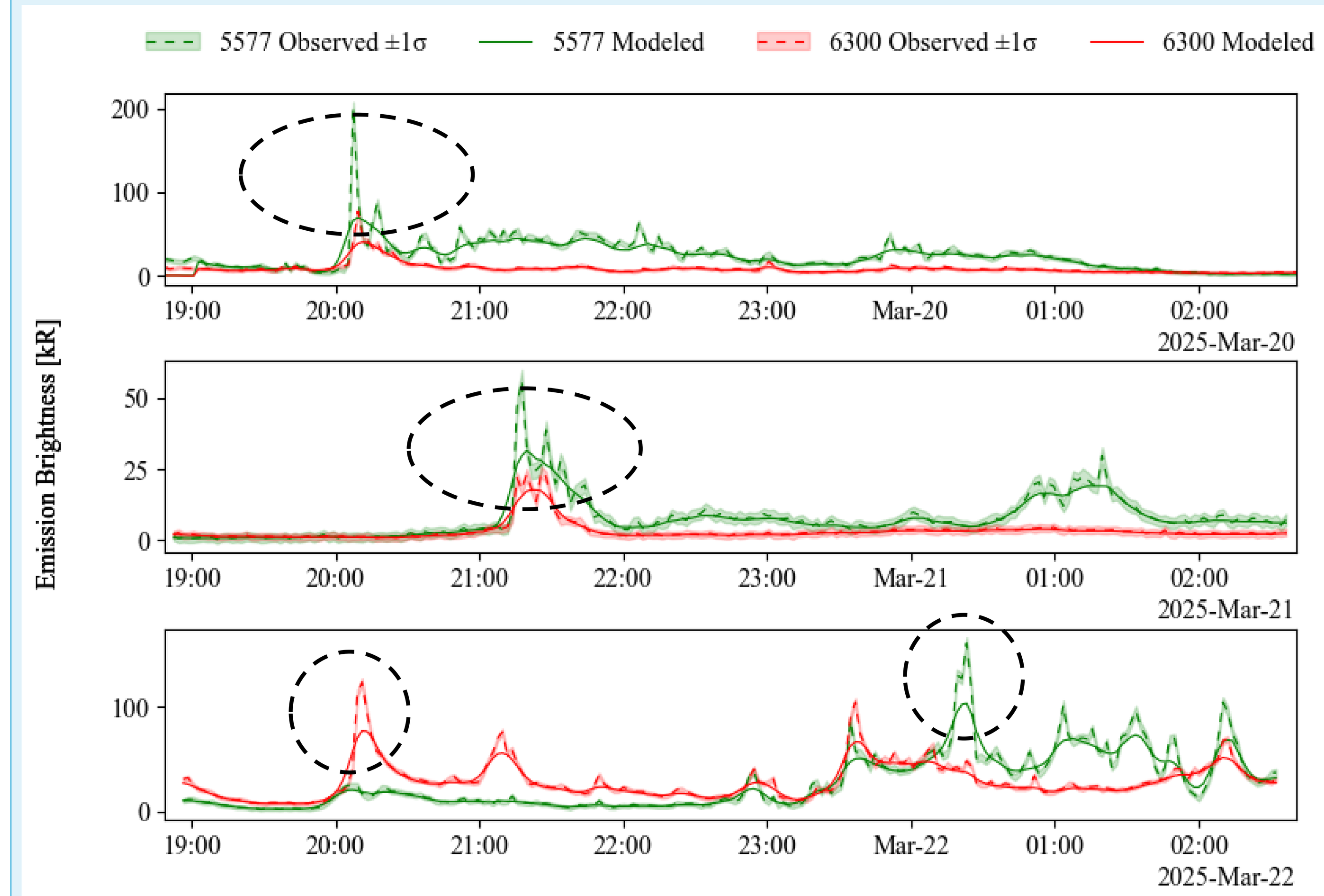


***Fig 4:** Each panel represented a different day and compares the modeled and measured brightness for red (6300 Å) and green line (5577 Å) emissions. Black ovals show underfitting during sudden enhancements.*

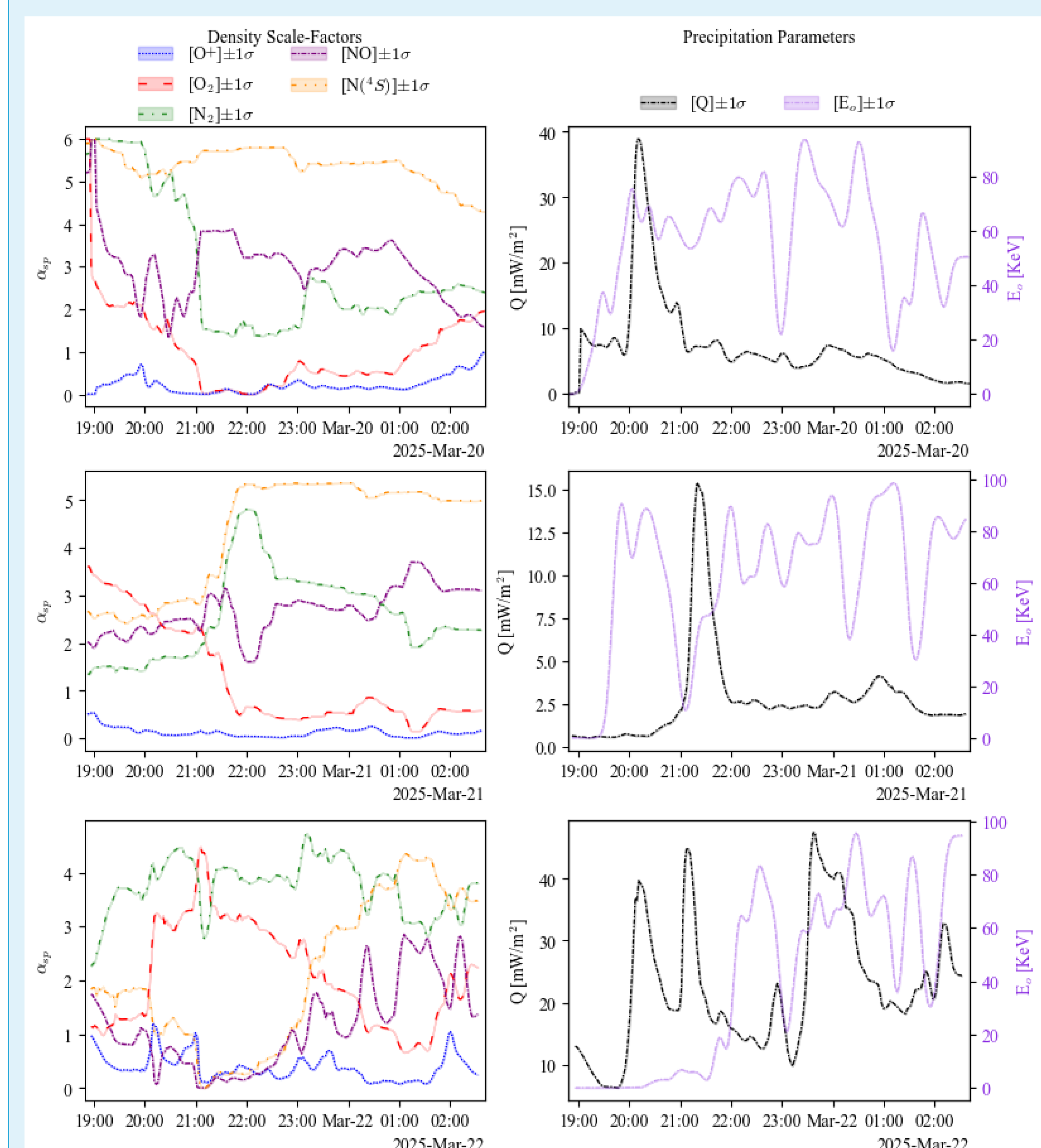


***Fig 5:** Each Panel shows a different day. **Left** – shows the optimal α_{sp} for all neutral species. **Right** - shows the optimal Q and Eo.*

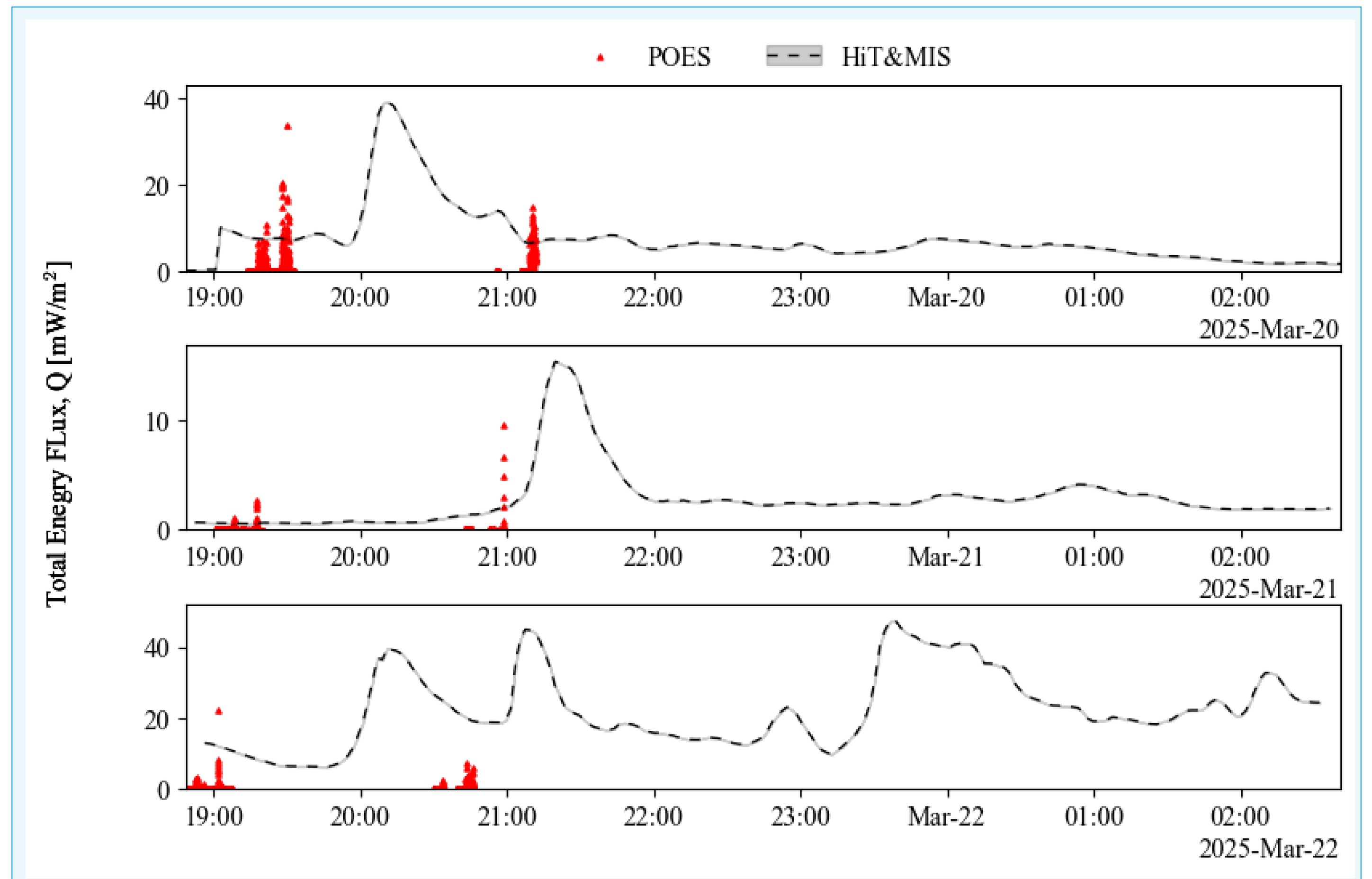


***Fig 6:** Q measured by POES compared to Q derived from HiT&MIS data.*

V. DAYTIME

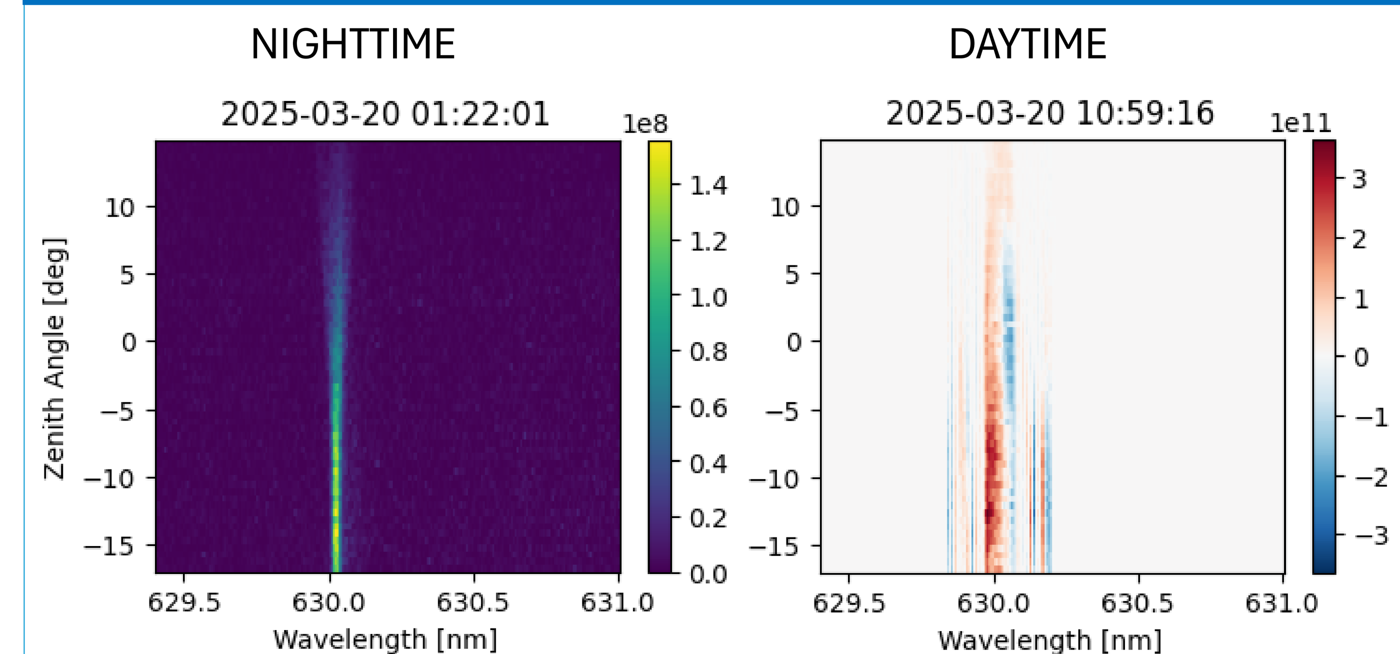


***Fig 7**: Comparison of daytime and nighttime Level 2 frame.*

VI. TAKEAWAYS

1. A robust analysis pipeline has been developed to estimate auroral precipitation parameters (total energy flux **Q** and characteristic energy **E_0**) from ground-based imaging spectrograph measurements.
2. Daytime retrieval is possible but requires the development of a scaling algorithm that minimizes bias.
3. HiT&MIS demonstrates a year-round capability for monitoring auroral emissions and upper-atmospheric energy input.

VII. REFERENCES

1 Pallamraju, D., Baumgardner, J. and Chakrabarti, S. (2002) 'HIRISE: A ground-based high-resolution imaging spectrograph using echelle grating for measuring daytime airglow/auroral emissions', *Journal of Atmospheric and Solar-Terrestrial Physics*, 64(12–14), pp. 1581–1587. doi:10.1016/s1364-6826(02)00095-0.'

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3 Chakrabarti, S., Jokiaho, O.-P., Baumgardner, J. L., Cook, T. A., Martel, J., & Galand, M. 2012, Optical Engineering, 51, 1

4 Toyomasu, S., et al. "Low-cost webcast system of real-time all-sky auroral images and MPEG archiving in Kiruna." *Proceedings of 33rd Annual European Meeting on Atmospheric Studies by Optical Methods, Kiruna*. Vol. 292.

5 Mukherjee, S. K. (2025). glowpython2: A Python Wrapper for the GLOW Model (v0.0.1) [Computer software]. GitHub. https://zenodo.org/badge/latestdoi/1026267765